Report for 2003KS33B: A Field Assessment of a Method for Estimation of Ground-Water Consumption By Phreatophytes: Methodology Refinement and Extension to Areas of Salt-Cedar Infestation

Publications

- Conference Proceedings:
    - Arnold, D., and J.J. Butler, Jr., Salt-cedar control activities and water-table monitoring on the Arnold Ranch, Clark County, Kansas, an invited presentation to the CPR for Wetlands and Streams II Conference, Wichita, KS, Sept. 28, 2005.
    - Bauer, J., Evaluating the effectiveness of salt cedar control measures as a means of water conservation along the Cimarron River, Kansas, undergraduate honor's thesis, Department of Geological Sciences, University of Colorado at Boulder, October, 2005.
    - Butler, J.J., Jr., Whittemore, D.O., and G.J. Kluitenberg, Studies of ground-water consumption by phreatophytes in river valleys of Kansas (abstract), Trans. Kansas Academy Science, v. 108, no. 3/4, pp. 165-166, 2005.
    - Butler, J.J., Jr., Whittemore, D.O., and G.J. Kluitenberg, A field investigation of ground-water consumption by phreatophytes in river valleys of Kansas (abstract), 50th Annual Midwest Ground Water Conf., Program with Abstracts, Illinois State Geol. Survey OFS 2005-13, p. 18, 2005.
    - Butler, J.J., Jr., Whittemore, D.O., and G.J. Kluitenberg, A field investigation of ground-water consumption by phreatophytes, presentation at the 14th Annual Kansas Hydrology Seminar, Topeka, November 18, 2005.
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    - Keller, J., Shea, J., Bauer, J., Butler, J.J., Jr., Kluitenberg, G.J., and D.O. Whittemore, A field investigation of the influence of spatial variability in hydraulic properties on phreatophyte-induced fluctuations in the water table (abstract), 50th Annual Midwest Ground Water Conf., Program with Abstracts, Illinois State Geol. Survey OFS 2005-13, p. 19,

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  - Kluitenberg, G.J., Butler, J.J., Jr., and D.O. Whittemore, A field investigation of major controls on phreatophyte-induced fluctuations in the water table (abstract), Annual Meetings Abstracts [CD-ROM], ASA, CSSA, and SSSA, Madison, WI, 2005.
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- Other Publications:
  - Bauer, J., Shea, J., Keller, J., Butler, J.J., Jr., Kluitenberg, G.J., and D.O. Whittemore, Diurnal water table fluctuations: An underutilized indicator of ground-water consumption by plants (abstract), Eos, v. 86, no. 52, Fall Meet. Suppl., Abstract B23A-1038, 2005.
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- Articles in Refereed Scientific Journals:
  - Butler, J.J., Jr., Kluitenberg, G.J., Whittemore, D.O., Loheide, S.P., II, Jin, W., Billinger, M.A., and X. Zhan, A field investigation of phreatophyte-induced fluctuations in the water

table, Water Resour. Res., pending revisions.

- Loheide, S.P., II, Butler, J.J., Jr., and S.M. Gorelick, Estimation of groundwater consumption by phreatophytes using diurnal water table fluctuations: A saturated-unsaturated flow assessment, Water Resour. Res., v. 41, W07030, doi:10.1029/2005WR003942, 2005.

Report Follows

KWRI PROGRESS REPORT – YEAR THREE

Project Title: A Field Assessment of a Method for Estimation of Ground-Water Consumption by Phreatophytes: Methodology Refinement and Extension to Areas of Salt-Cedar Infestation
Duration of Reporting Period: March 1, 2005 - February 28, 2006
Federal Funding for Reporting Period: $8,450
Investigators and Affiliations: James J. Butler, Jr., Kansas Geological Survey (PI), Gerard J. Kluitenberg, Kansas State University (Co-PI), Donald O. Whittemore, Kansas Geological Survey (Co-PI).
Research Category: Statewide Competitive Grant
Descriptors: phreatophytes, ground water, evapotranspiration, water balance

PROBLEM AND RESEARCH OBJECTIVES

Low streamflows are an increasing problem in Kansas and other areas of the U.S. As a result, smaller amounts of water are available for diversions to water supplies and wetlands, for inflows to reservoirs, for capture by wells in nearby aquifers, for sustaining aquatic wildlife, and for recreation. Stream-aquifer interactions play an important role in the generation and maintenance of low streamflows. Ground-water development in regional aquifers that discharge water to stream corridors and in alluvial aquifers immediately adjacent to streams is often a major factor responsible for low-flow periods. However, consumption of ground water by phreatophytes in riparian zones could also be an important contributor to reduction of stream flow. Recently, partly in response to concerns about water consumption, expensive measures for phreatophyte control have been advocated for stretches of rivers in western Kansas.

Present understanding of phreatophyte activity in stream-aquifer systems in Kansas is insufficient to assess the magnitude of that activity. This project is directed at refining methodologies for quantitative assessment of phreatophyte activity, and utilizing those methods to assess water savings as part of a demonstration of salt-cedar control measures along the Cimarron River. Specifically, the major objectives for the project are to 1) refine methodologies for quantifying the consumption of ground water by phreatophytes, and 2) use these methods to determine ground-water savings produced by control of invasive phreatophytes (salt cedar and Russian olive) along a portion of the Cimarron River in Kansas. An auxiliary objective of this work is to gather a detailed data set on the major fluxes in stream-aquifer systems that can serve as the basis for research proposals on the quantitative assessment of stream-aquifer interactions in settings common to the Great Plains.

The six activities proposed for the third year of this project were as follows:

1. Monitoring of water levels and meteorologic parameters at both the Larned Research Site and the Ashland Research Site;
2. Monitoring of vadose-zone moisture during the growing season at both sites;
3. Determination of specific yield through use of moisture-content profiles and water-table changes (Skaggs et al., 1978) and other methods (Loheide et al., 2005);
4. Use water-table fluctuations to assess phreatophyte activity at both sites;

5. Characterize the initial soil-moisture and ground-water savings produced by the control activities at the Ashland Research Site;

6. Assess phreatophyte activity in the Arkansas River riparian zone from Kinsley to Great Bend.

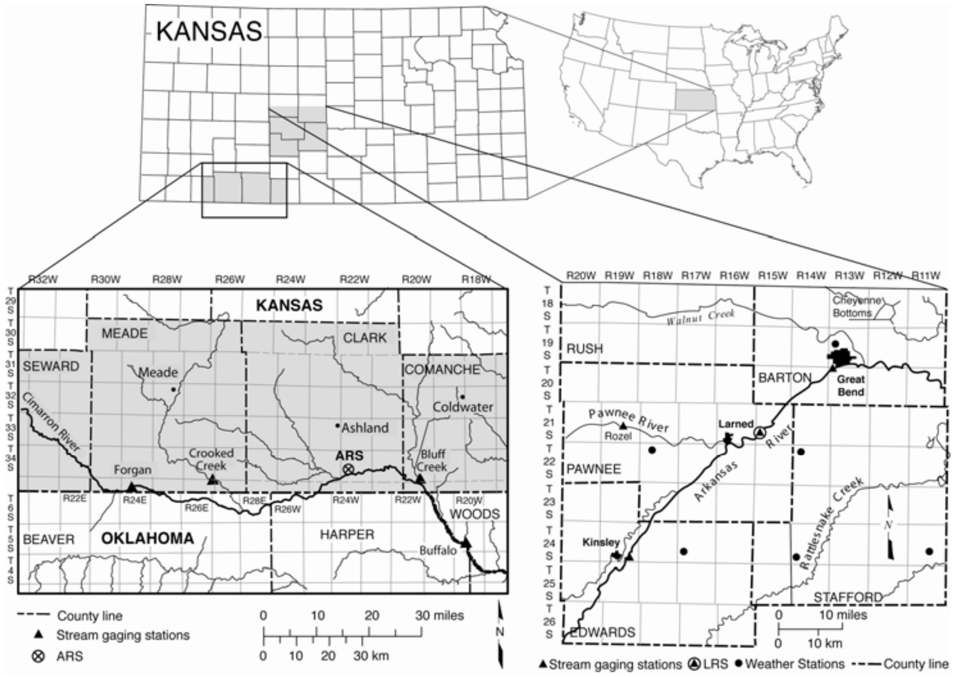


Figure 1

METHODOLOGY

The ultimate objective of this project is to develop a practical approach for quantifying phreatophyte consumption of ground water. This work is being done at two Kansas Geological Survey (KGS)/Kansas State University (KSU) research sites: the Larned Research Site (LRS) located adjacent to the United States Geological Survey stream-gaging station on the Arkansas River near Larned in central Kansas, and the Ashland Research Site (ARS) located along the Cimarron River south of Ashland in southwest Kansas (Figure 1). The KGS/KSU research team focused on the LRS in the first two years of the project and then expanded the scope of the project in year three to include the ARS. The vegetation at the LRS is dominated by phreatophytes that are native to the Arkansas River riparian zone (cottonwood, willow, and mulberry), while the ARS is dominated by invasive phreatophytes (salt cedar and Russian olive).

A series of shallow wells have been installed at the LRS and ARS to monitor the position of the water table through time. All wells are equipped with integrated pressure transducer/datalogger units (In-Situ MiniTroll) that are programmed to take pressure-head readings every 15 minutes. Since riparian-zone wells can be overtopped during periods of high stream flow, absolute pressure sensors are used at most wells (12 out of 19 wells at the LRS and all six wells at the ARS) instead of the standard gauge-pressure sensors. The absolute-pressure sensors measure the pressure exerted both by

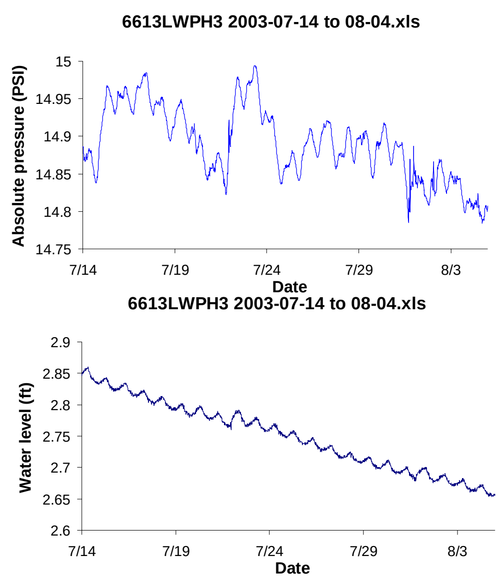


Figure 2 – Barometric pressure correction at LRS well LWPH3.

the height of the overlying column of water in the well and by the atmosphere. The atmospheric pressure component was removed using data from a barometer at the site. Figure 2 displays records from an absolute-pressure sensor in the riparian zone at the LRS prior to and after the barometric pressure correction. Manual measurements of water levels in the monitoring wells were taken biweekly during the summer and bimonthly otherwise to assess the performance of the pressure sensors and, if necessary, to adjust the calibration parameters. Three barometers were maintained at each site to ensure data collection was not impacted by failure of a barometer. Barometer performance at each site was assessed through a comparison of the three site barometers. In addition, a handheld barometer was used to assess sensor performance during site visits. Two wells were added to the LRS network in year three to assess the role of water flow through the aquitard underlying the Arkansas River alluvial aquifer in the riparian zone.

A series of neutron-probe access tubes (eight access tubes at the LRS and six at the ARS) have been installed at each site so that volumetric moisture content can be measured at biweekly intervals during the growing season. Measurements in the access tubes were recorded with a neutron probe (Model 503 DR Hydroprobe Moisture Depth Gauge; Campbell Pacific Nuclear) using a count duration of 16 s and depth increments of either 0.076 m or 0.152 m. Standard counts were recorded in the field both prior to and after access tube measurements. The mean standard count for the duration of the study was used to convert each measured count to a count ratio (CR). The soil volumetric water content ($m^3\ m^{-3}$), θ, corresponding to each measured count ratio was calculated with the calibration equation $\theta = 0.2929 \times CR - 0.0117$, which was based on laboratory calibrations and an adjustment for PVC pipe.

Vertical profiles of specific conductance and temperature within individual wells were measured approximately biweekly during the summer and monthly to quarterly during the remainder of the year in the LRS riparian-zone wells and all wells at the ARS using a YSI Model 30 meter and 50 ft cable. Specific conductance and temperature were recorded at the same time interval as pressure head in two LRS and one ARS wells using integrated multiparameter probe/datalogger units (two In-Situ MP Troll 9000 units and one YSI 600SL Sonde).

Tree inventories were performed at both the LRS and ARS in year three. At the LRS, a detailed tree inventory was performed over the full width of the riparian zone in the same area in which a tree inventory was performed in the summer of 2002. A total of 864 trees with trunk diameters larger than 0.08 m at chest height were counted, identified, and tagged in 2002. Of those trees, 810 were found again in 2005 and their health was characterized using a six category classification system based on observed foliage (fully alive, <20% dead, 20-50% dead, 50-80% dead, > 80% dead, and fully dead). At the ARS, an inventory of salt cedar and Russian olive within 45 ft (13.7 m) of wells Ash12, 21, 22, and 31 was performed using four height classes (<3 ft, 3-6 ft, 6-9 ft, >9 ft).

Weather stations (Hobo Weather Station logger and sensors, Onset Computer Corp.) were in operation at both sites during year three. The weather stations are equipped with sensors to measure precipitation, air temperature, relative humidity, global irradiance [direct and diffuse solar irradiance], wind speed and direction, and barometric pressure. The barometric pressure sensor was added to both weather stations in early summer of year three. Data are averaged (air temperature, global irradiance, barometric pressure, and wind speed and direction) or summed (precipitation) and logged at a 15-minute interval. The only exception is the relative humidity sensor, which provides a single measurement at the end of the 15-minute interval. Potential evapotranspiration was calculated from the meteorologic data using the Penman-Monteith equation. The wind speed and direction sensor failed abruptly at the LRS in November of 2005 and caused the datalogger to shut down. Data from a weather station located at a distance of approximately 10 kilometers from the site will be used to fill in the data gap caused by sensor failure and logger shutdown.

MAJOR ACTIVITIES AND PRINCIPAL FINDINGS

The principal findings of the third year of the project will be briefly discussed in the context of the six activities proposed for year three:

Activity 1: Monitoring of water levels and meteorologic parameters at both the Larned Research Site and the Ashland Research Site – Pressure-head measurements were obtained at 15-minute intervals at 19 wells at the LRS and six wells at the ARS. Meteorologic parameters were measured at 15-minute intervals at weather stations at both sites. There was no flow in the Arkansas River at the LRS at any time during year three, but there was flow in the Cimarron River at the ARS throughout the year. A paper primarily based on the LRS and ARS data was prepared and submitted to Water Resources Research in year three. A revised form of that paper is currently in review at Water Resources Research. Figure 3 is a figure from that paper in which the link between the sapflow velocity measured in a LRS cottonwood and water-table fluctuations is illustrated (fluctuations are virtually nonexistent during period of low sapflow).

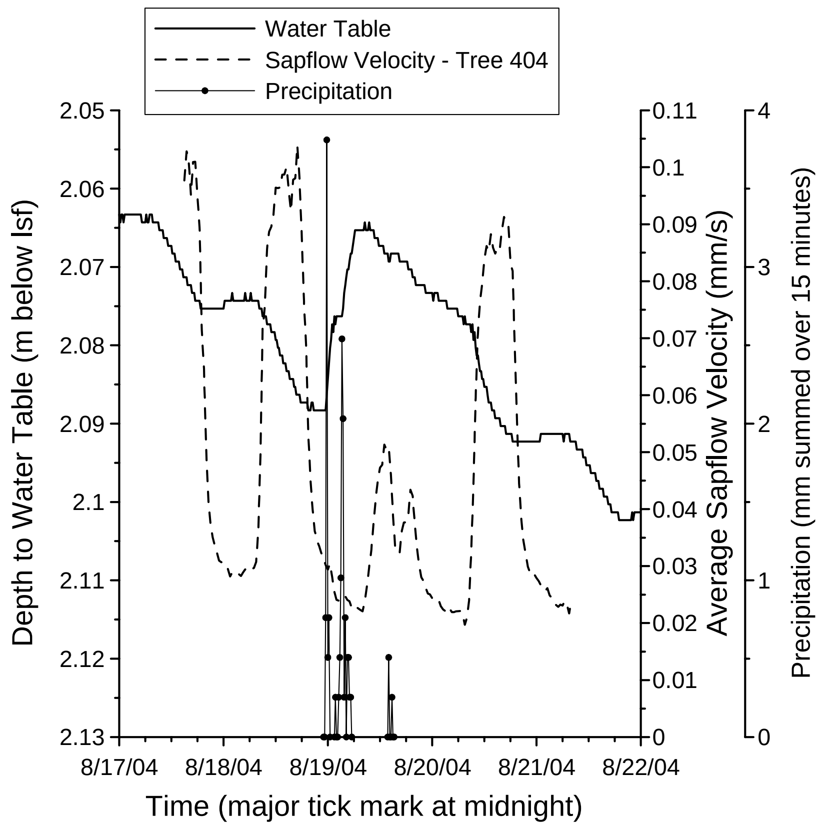


Figure 3 – Depth to water table from land surface at well LWPH2 in LRS with sapflow velocity from nearby cottonwood and precipitation from LRS weather station.

Activity 2: Monitoring of vadose-zone moisture during the growing season at both LRS and ARS – Vadose-zone moisture was monitored biweekly during the growing season at eight locations (four adjacent to monitoring wells) at the LRS and six locations (adjacent to monitoring wells) at the ARS. Figure 4 is an example of the data that were obtained. This figure displays the volumetric moisture content measured near well LWPH3 at the LRS, illustrating the wetting of the near-surface profile associated with late spring and late summer rains, and the dry down in the intervening period.

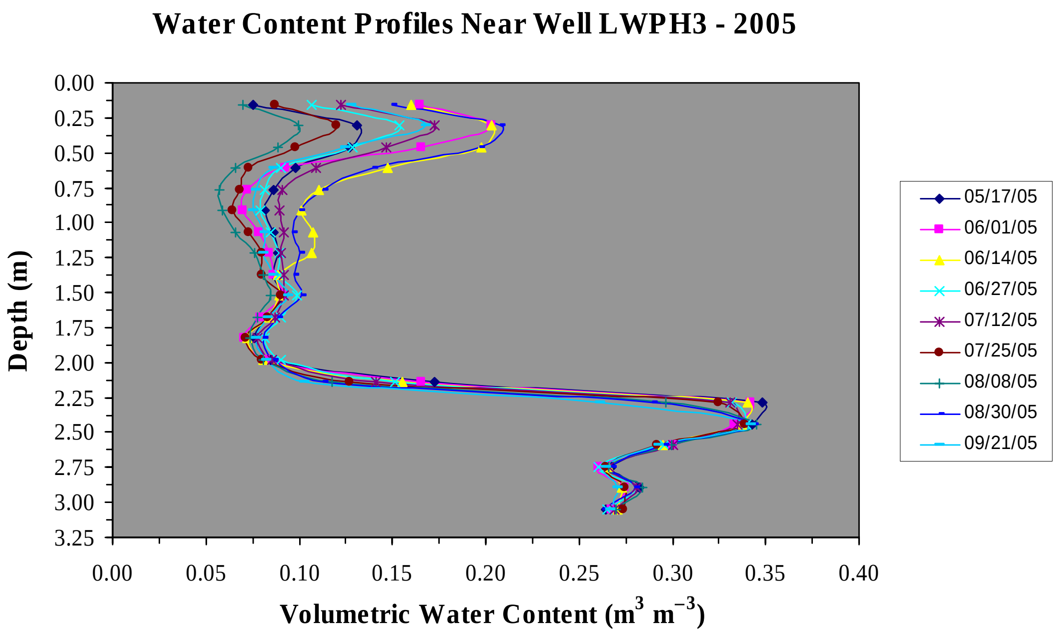


Figure 4 – Water content profiles near LWPH3 for 2005 growing season.

Activity 3: Determination of specific yield through use of moisture-content profiles and water-table changes (Skaggs et al., 1978) and other methods (Loheide et al., 2005) – The method of Skaggs et al. (1978) requires periods of rapid water-table change so that soil-moisture changes due to drainage/wetting will dominate over changes produced by plant water use. There were no such periods at the LRS or ARS in year three, so this method could not be used to estimate specific yield from data collected in year three. Additional data from earlier years were used to expand the LRS specific-yield database, but the ARS moisture-content data set was not amenable to such an analysis. Alternative approaches for estimation of specific yield (e.g., Loheide et al., 2005) require information on sediment texture. Samples were taken adjacent to each of the monitoring wells at the ARS to assemble a data set that could be used for that purpose. At each site, four sampling locations were identified at a distance of approximately 10 feet (3.05 m) from the well. Sampling locations were distributed as uniformly as possible around each well (ideal arrangement forming a square); however, the spatial arrangement varied from well to well due to the presence of plants and landscape features. Samples were collected (2.75-inch (0.070-m) diameter bucket auger) from all four sampling locations in 6-inch (0.152-m) depth intervals from the soil surface to the maximum depth allowable due to the presence of the water table. The samples obtained from the four sampling locations were combined (composited) by depth interval and then transported to the KSU Soil Testing and Soil Characterization Laboratories for analysis. The results of those analyses will be used in year four to aid in estimation of specific yield at the ARS.

Activity 4: Use water-table fluctuations to assess phreatophyte activity at LRS and ARS – This activity was a continuation of a major focus of both theoretical and field work in year two. As discussed under activity one, a paper largely based on the LRS and ARS data was prepared and submitted to Water Resources Research in year three. The primary focus of this paper was the assessment of the major controls on the water-table fluctuations and the ecohydrologic insights that can be gleaned from them. We found that spatial and temporal variations in the amplitude of the fluctuations are primarily a function of variations in 1) the meteorological drivers of plant water use; 2) vegetation density, type, and vitality; and 3) the specific yield of sediments in the vicinity of the water table. Past hydrologic conditions experienced by the riparian-zone vegetation, either in previous years or earlier within the same growing season, are also an important control. We concluded that diurnal water-table fluctuations can be considered a diagnostic indicator of ground-water consumption by phreatophytes at most sites, so the information embedded within these fluctuations should be more widely exploited in ecohydrologic studies.

Figure 5
Comparison of Well Ash12
and Well Ash22 - Pre-Control

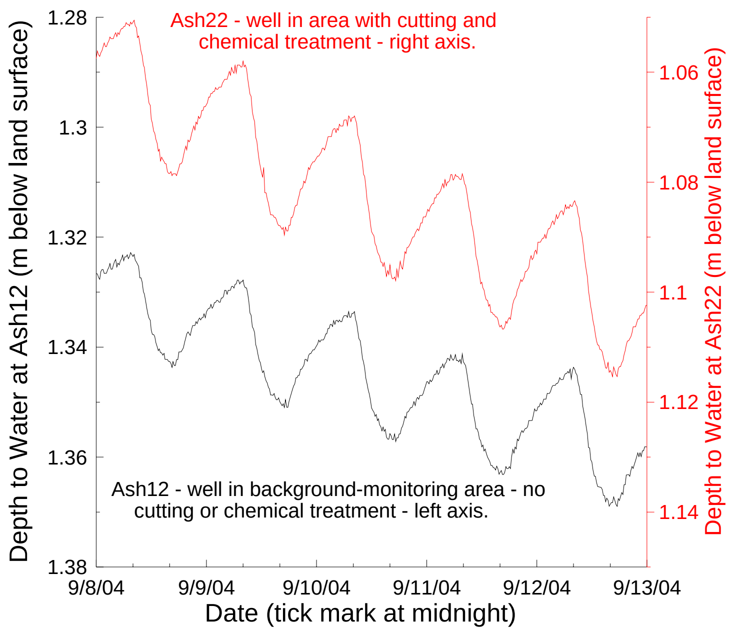
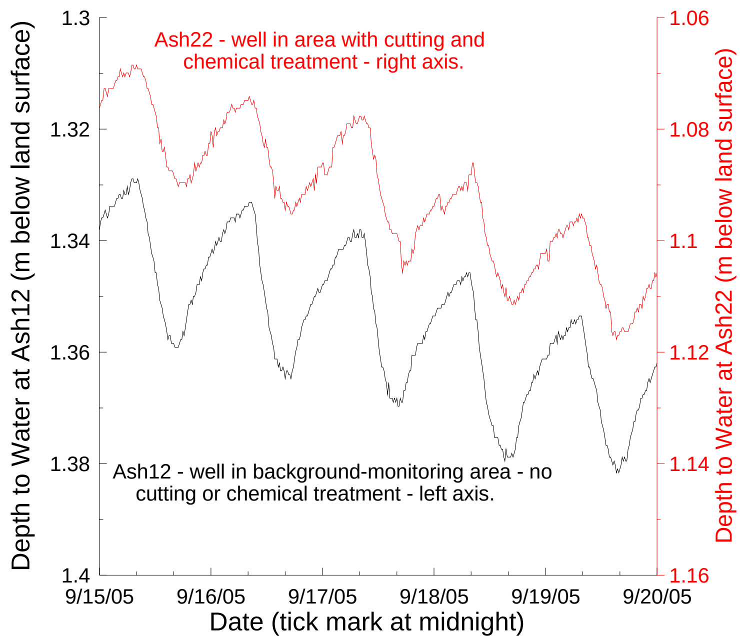


Figure 6
Comparison of Well Ash12
and Well Ash22 - Post-Control



Activity 5: Characterize the initial soil-moisture and ground-water savings produced by the control activities at ARS – This activity was a major focus of year three. The ARS is subdivided into four plots of approximately four hectares each in which different salt-cedar control measures were applied. Control measures were not used in Plot 1 (plot with wells Ash11 and Ash12) so that data unaffected by those measures could be obtained throughout the project. Water-level data collected prior to any control activities clearly indicate that the magnitude of the water-table fluctuations is highly dependent on the apparent vitality of the phreatophyte community in the vicinity of each well. Salt-cedar control measures began to be implemented at the ARS in March of 2005. At that time, Plots 2-4 were clear cut except for circles ranging from 20-30 m in radius, centered at each well. The radii of those circles of vegetation were progressively reduced through repeated cuttings in the summer of 2005. Note that only the invasive phreatophytes (salt cedar and Russian olive) were cut at the site; grasses, forbs, and low-lying bushes were largely unaffected. A chemical treatment (Remedy and diesel-fuel mix) was applied to the salt-cedar regrowth in Plot 2 (plot with wells Ash21 and Ash22) following the cutting. Water levels, soil moisture, and meteorological parameters were monitored before, during, and after the control activities. Relationships were

established between water levels in the various plots prior to cutting through a comparison of water levels from wells in Plot 1 (background-monitoring plot) with those from wells in the other plots (Figure 5). Changes in those relationships after the cutting and chemical treatment (Figure 6 – note the reversal of the relative magnitudes of the fluctuations vis-à-vis those in Figure 5 for the same depth interval) enabled initial estimation of the resulting reduction of ground-water consumption. The reductions appear to be on the order of 30-50%. Apparently, the shallow depth to water at the ARS allows substantial ground-water consumption by other mechanisms, such as transpiration by shallow-rooted vegetation and direct evaporation from the water table. Planned work for year four of this project is directed at assessing the relative importance of ground-water consumption by these other mechanisms. Unless the impact of these mechanisms is better understood, it will be difficult to reliably estimate the potential water savings to be achieved through control of invasive phreatophytes.

Activity 6: Assess phreatophyte activity in the Arkansas River riparian zone from Kinsley to Great Bend – Observations in year three along the Arkansas River riparian zone between Kinsley and Great Bend indicated that there was significant mortality of the native phreatophytes. The tree inventory at the LRS provided some insight into the rate of this mortality. Figure 7 displays the results of the tree inventory summarizing the condition of the native phreatophytes at the LRS in the summer of 2005. Virtually all of the deterioration of tree health occurred since the 2002 inventory. Comparison of the tree inventories performed in the summers of 2002 and 2005 revealed a 20-25% mortality rate over the study period, with an additional 20% of trees under severe water stress. The native phreatophytes appear to be having difficulty keeping pace with the falling water table, leading to severe stress and a high rate of mortality. At present, the canopy is still sufficiently dense to prevent encroachment by salt cedar and Russian olive. However, if the present rate of mortality continues, non-native phreatophytes may be able to exploit open areas created by tree die-off, leading to large changes in the riparian-zone community between Kinsley and Great Bend.

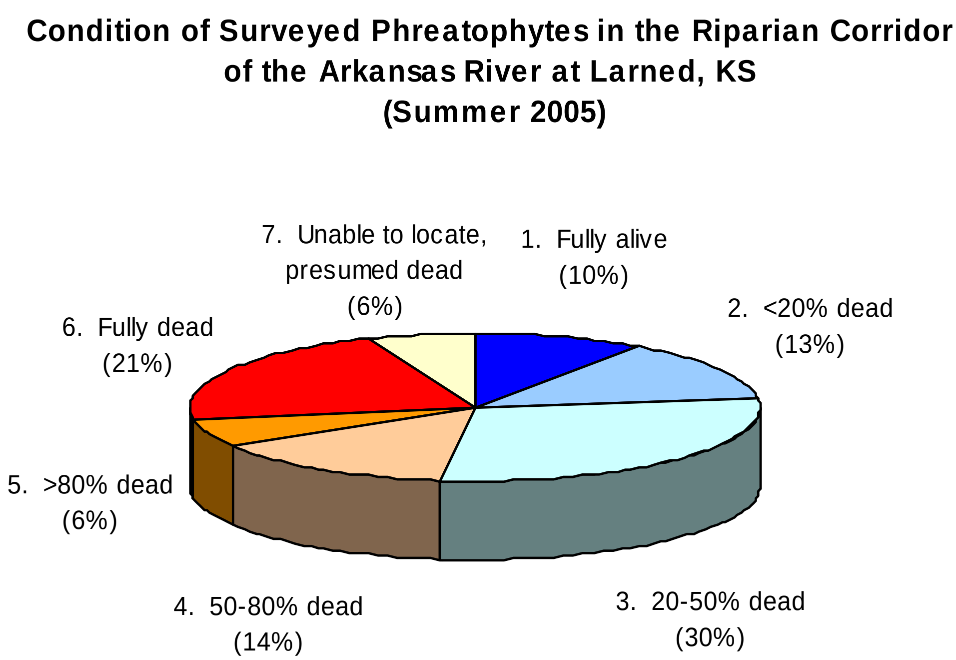


Figure 7

REFERENCES CITED

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Skaggs, R.W., Wells, L.G., and S.R. Ghate, Predicted and measured drainage porosities for field soils, Trans. ASAE 22, 522-528, 1978.

PAPERS AND PRESENTATIONS

Arnold, D., and J.J. Butler, Jr., Salt-cedar control activities and water-table monitoring on the Arnold Ranch, Clark County, Kansas, an invited presentation to the CPR for Wetlands and Streams II Conference, Wichita, KS, Sept. 28, 2005.

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INFORMATION TRANSFER

Thirteen presentations concerning this project were presented at various venues both within and outside of Kansas during year three. Three additional abstracts were prepared for presentations early in year four (Water and the Future of Kansas Conference - March 2006, Kansas Academy of Science Conference - April 2006). One manuscript reporting a modeling assessment of the White method for estimating groundwater consumption by phreatophytes from water-table fluctuations was published in the journal Water Resources Research in year three, and a second manuscript describing the results of the field investigation of phreatophyte-induced fluctuations in the water table was submitted to Water Resources Research and is currently undergoing revision.

STUDENT SUPPORT

Three students participating in the Applied Geohydrology Summer Research Assistantship Program of the Kansas Geological Survey were partially supported from this grant during the summer of 2005. These students contributed to the aspects of the project involving well and access-tube installation, water-level and vadose-zone monitoring, conductance measurements, and weather-station upkeep. One of the students, Jacob Bauer, used the summer program project for his undergraduate honors thesis in the Department of Geological Sciences at the University of Colorado at Boulder. His thesis was awarded the summa cum laude designation.